

Evaluating Changes in Landscape-scale Organic C Due to Tillage

Dennis E. Rolston
Land, Air and Water Resources
University of California, Davis

Research Team

Faculty

Dennis Rolston

Johan Six

Chris VanKessel

Jan Hopmans

Richard Plant

Kyaw Tha Paw U

Ted Hsiao

PGRs, SRAs, GSRs

Amy King

Jeannie Evatt

Dianne Louie

Guy Shaver

Alan Idris

Juhwan Lee

Tony Matista

Jim MacIntyre

Several undergrads

Grower Cooperators

- **Tony Turkovitch and Martin Medina of Button and Turkovitch, Winters, CA**



Funding Sources

- **Kearney Foundation of Soil Science**
- **CA Dept of Food and Agriculture**
- **CA Energy Commission**

Soil Carbon and Tillage

- Studies in the Midwest indicate that considerable C can be sequestered by conservation tillage practices
- How about in California?
 - Need to occasionally reform beds and furrows
 - Higher mean annual soil temperature

Conservation tillage practices have increased by 300% in the Midwest during the last decade.

In California however, less than 0.3% of crop acreage is farmed using conservation tillage practices (courtesy of Jeff Mitchell).

(Conservation tillage Information Center, Lafayette, IN, 2002)

Minimum tillage could have large impacts on water and air quality



WANT LOCAL NEWS ONLINE?
fresnoBee.com



Betty Kemmerl

30 years of talk hasn't cleared air

Nearly 30 years after the San Joaquin Valley was first designated as a "serious non-attainment area" for particulate matter, the valley's air quality remains poor. ...

LATE FINAL EDITION

The key to finding the right couch is a little bit of patience and a clear sofa goal.

HAGHER

Board takes up dust rule today

Session added to OK nine changes and prepare for approval.

By MARK GRONAU AND BARBARA ANDREASIN THE FRESNO BEE

The San Joaquin Valley's dust rule — already four years late — has hit a last track, with the local air board adding a revision this af-

Bulldogs Charles this w...



In front of Fresno City Hall after the car smashed into the hall doors, police...

at a woman who high downtown.

... at a woman who high downtown. ... Police officers and public safety personnel dozens of people to spill out of downtown Multnomah Mall office buildings. They started in downtown police closed F Street and police officers attended to LaCenta ...



Name Marie LaCenta, 41, who was ... ing Wednesday. It carried away from Center. She was reported in ...

EPA wants Valley farmers to seek air pollution permits

By MARK GRONAU THE FRESNO BEE

... The EPA report is expected to appear this week in a ...

LATE FINAL EDITION

Levy case revived as Rep. Gary Condit is issued a subpoena by a grand jury. PAGE A4

Air board approves dust rule for Valley

Critics, though, say they were left out of talks on the long-debated issue.

By MARK GRONAU AND BARBARA ANDREASIN THE FRESNO BEE



SECTION OBITUARIES • 4
CRIME • 6
WEATHER • 8

AIR QUALITY EPA sued for delay in Valley

Agency is failing to protect the public, groups allege.

By MARK GRONAU THE FRESNO BEE

... (Continued) medical and environmental groups sued the federal government Thursday over the San Joaquin Valley's air, alleging years of cleanup delays ...

“The San Joaquin Valley is currently classified as a serious non-attainment region for PM10 under both state and federal standards. “

Objectives

- Quantify C input pathways and their spatial and temporal variations at field scale
- Determine effects of tillage on the spatial distribution of **short-term** rates of C cycling and greenhouse gas emissions
- Improve existing models to predict **long-term** soil C sequestration and greenhouse gas emissions at field scale following implementation of minimum tillage

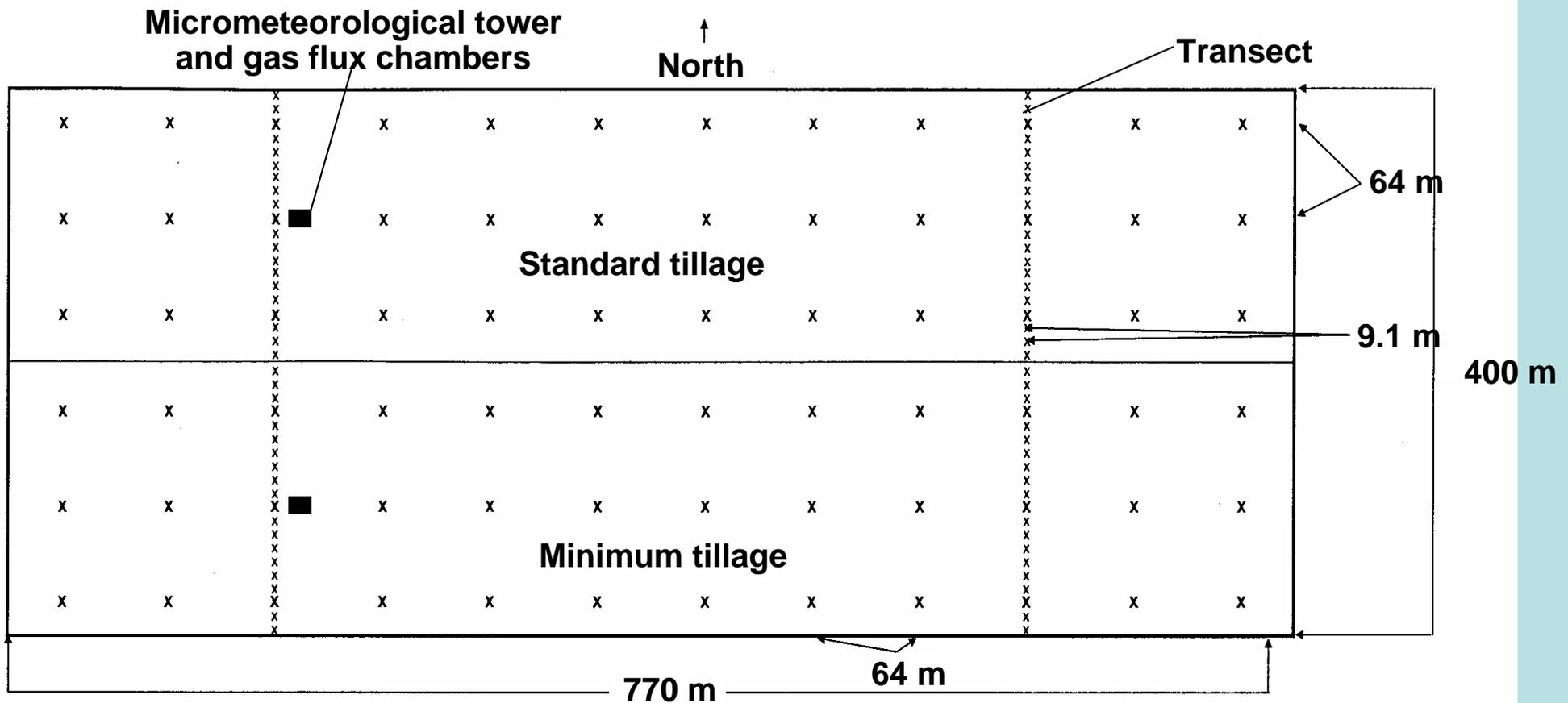


Figure 1. Field diagram showing the 140 soil sampling locations. The micromet towers, automated chambers, and below ground sampling locations are located near the west transect in the middle of each field.

Total field area = 30.8 ha

Intensive Soil Sampling with a Geoprobe

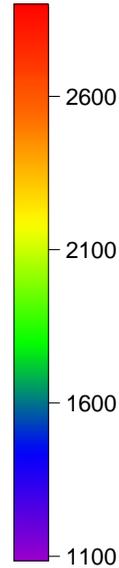
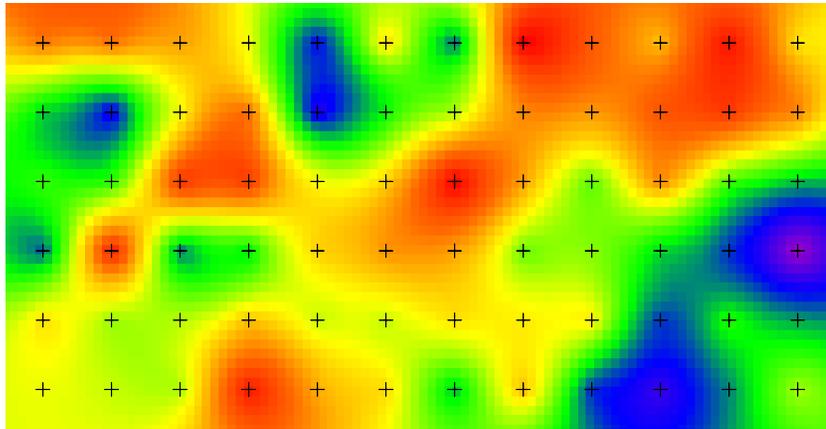
- 140 sites sampled 8/03, prior to tillage operations
- Sampled to 1 m depth with a Geoprobe
- Soil samples from 5 depths (0-15, 15-30, 30-50, 50-75, and 75-100 cm)
- Analyzed for physical/chemical properties as well as C and N content
- Intensive sampling again in '06



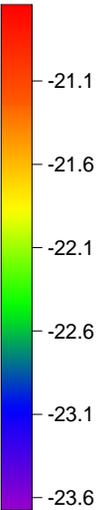
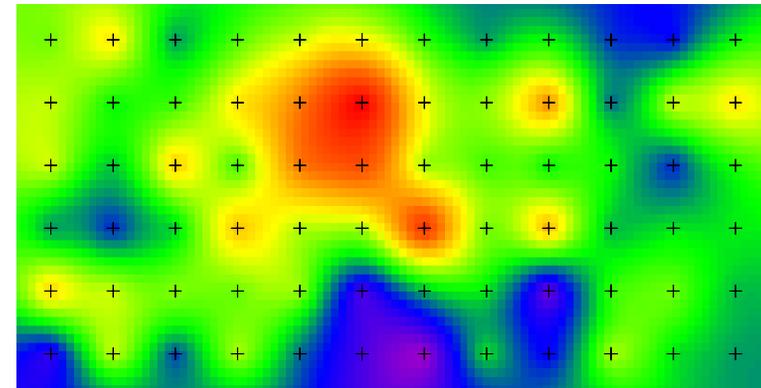
Turkovich Farm, August 2003

Distribution of soil C and N at the 0-15 cm depth

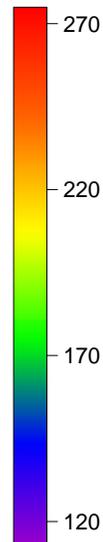
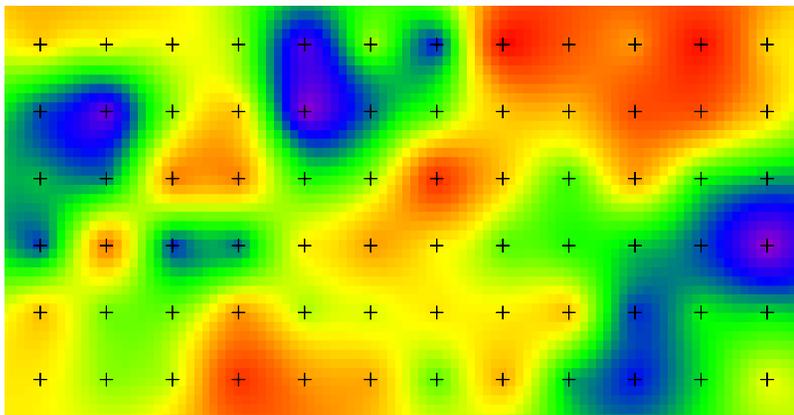
Total C (g C/m²), 0-15 cm



Delta 13C, 0-15 cm



Total N (g N/m²), 0-15 cm



Hand harvesting for grain & biomass

June 2003



Wheat crop prior to tillage



Residue control

Sept.-Oct.
2003



Decreased wheat and corn biomass by 40 and 65%, respectively.

Standard Tillage - October 2003



Minimum till and standard till fields



Corn planted the following April (2004)

Measurements

- **Soil sampling for physical, chemical, and biological variables including soil C and N**
- **Environmental variables such as rain + irrigation, ET, air temp, humidity, net radiation**
- **C inputs from crops and weeds, residue incorporation**
- **CO₂ exchange with vegetation and soil**
- **Greenhouse and trace gas emissions from soil – CO₂, N₂O, CH₄, NO**

Eddy covariance measurement system

One tower in each field

Spatial measurement scale=several ha



- Wind velocity in 3D
- CO₂ concentration and flux
- Air & surface soil temperature
- Soil heat flux
- Net radiation
- Relative humidity



Automated chamber

- Chamber closed for 1 min, open for 30 min
- Fans to mix gas in chamber
- CO₂ concentration measured by IRGA
- Spatial measurement scale=0.62 m²
- Temporal patterns

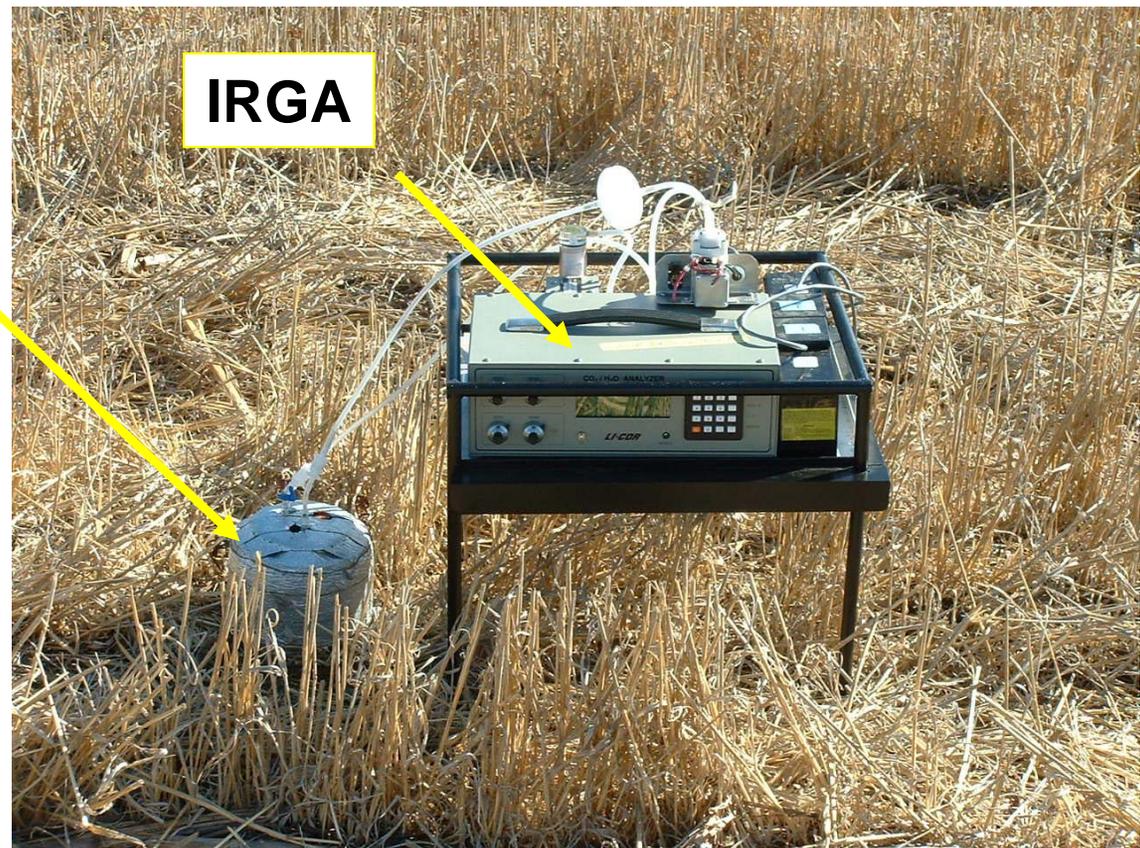


Small chambers for CO_2 and N_2O fluxes

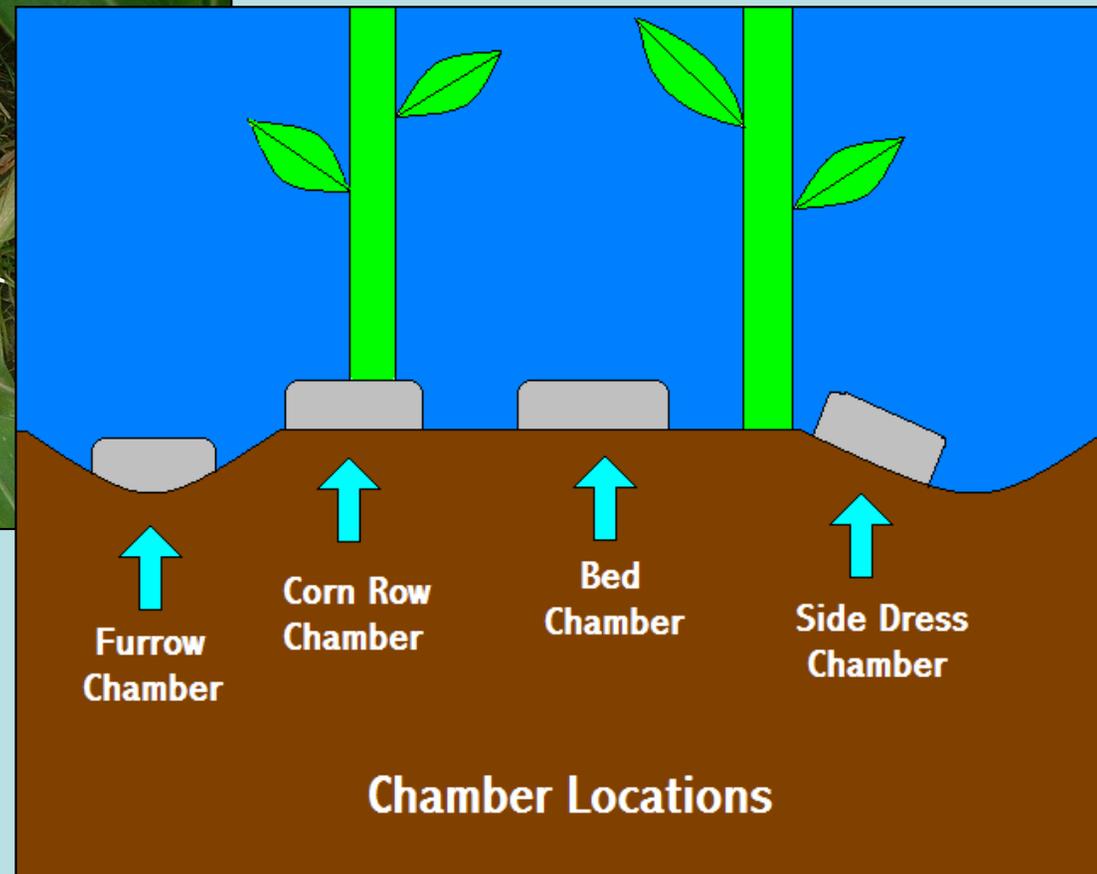
- CO_2 concentration in chambers measured by IRGA
- N_2O concentration sampled with syringes and analyzed by GC
- Gas fluxes calculated from increase in concentration with time
- Many small chambers employed to determine spatial patterns

Small, insulated chambers

Spatial measurement
scale = 0.012 m^2



PVC chambers (0.05 m²) with portable lids are sampled routinely for both CO₂ and N₂O



Comparisons of flux measurements

- Mean CO₂ flux in micromoles CO₂ m⁻² s⁻¹ for three measurement systems on [November 21, 2003](#). Standard deviations are in parentheses.
- Fluxes before tillage were about 1.0 for both micromet & automated chambers
- Comparisons at other times are in fairly good agreement also

	n	12-8 pm	2-4 pm	3-4:30 pm
No-till tower	1	1.36 (0.55)	1.36 (0.4)	
Till tower	1			1.36
No-till auto chamber	1	1.31	1.47	
Till auto chamber	2	2.51	3.11	
No-till portable chamber	4		1.33 (0.51)	
Till portable chamber	4		1.19 (0.17)	

Below ground measurements

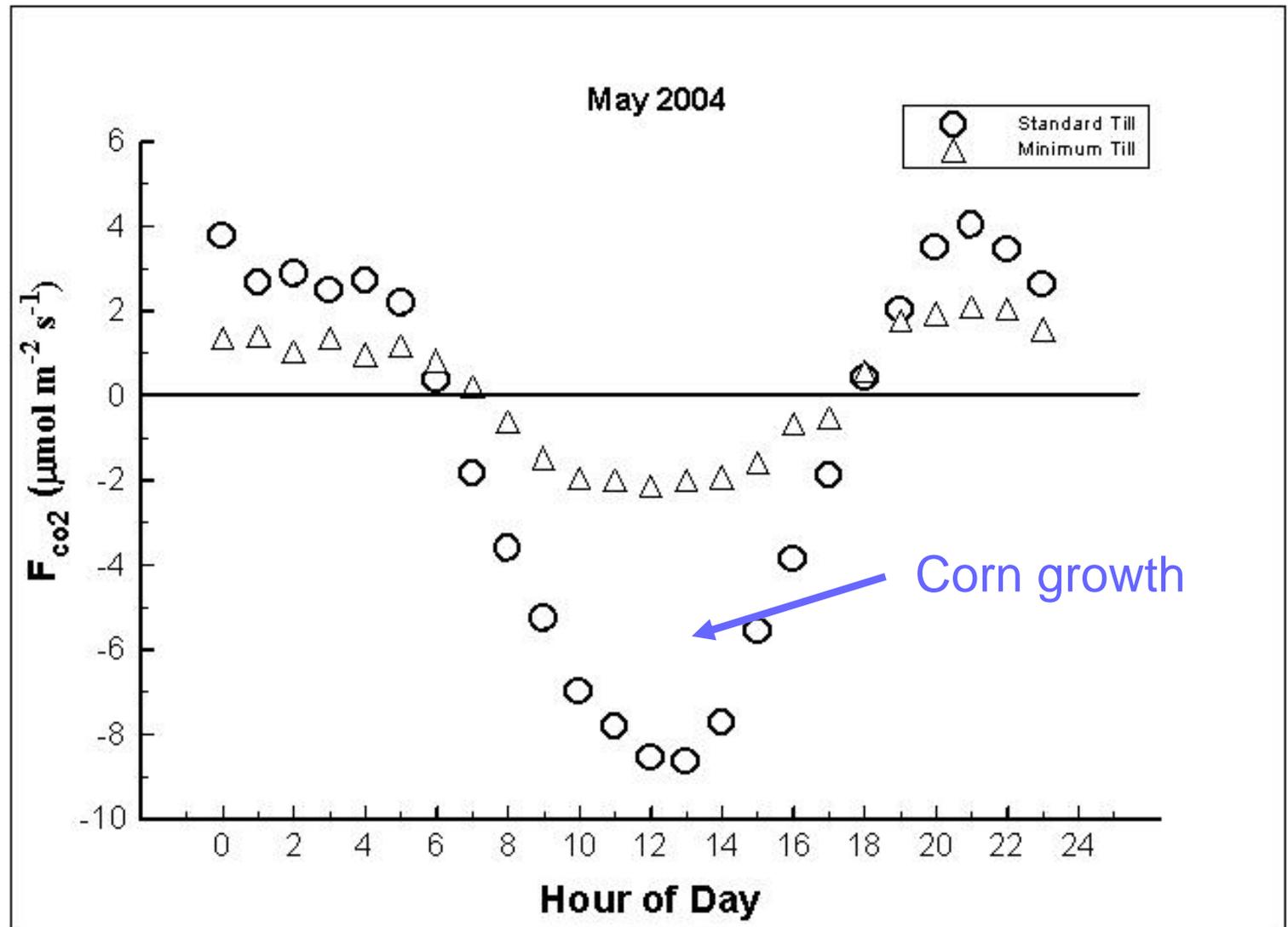
- Temperature
- Water content
- Water potential
- Air pressure
- CO₂ concentration
- N₂O concentration

Probes in furrow

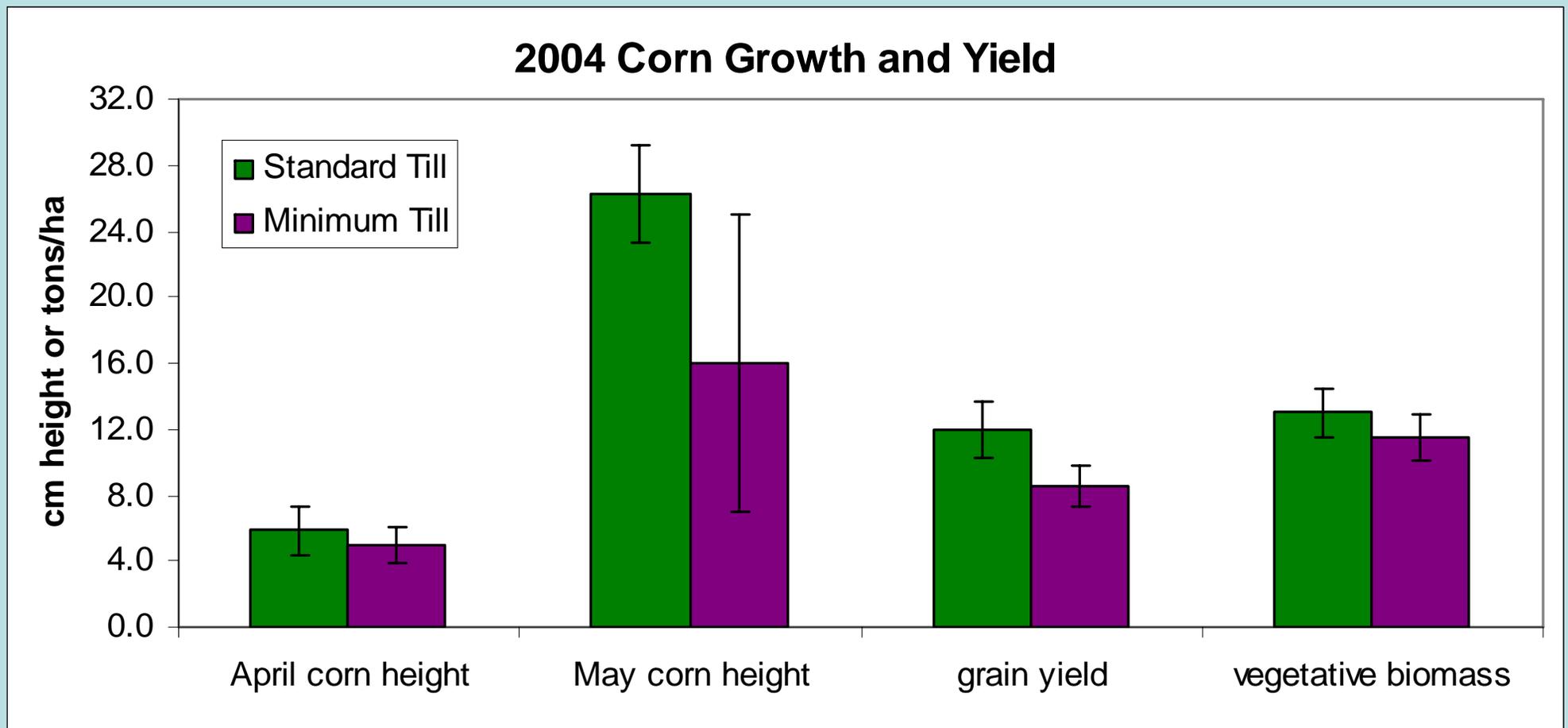


Mean monthly CO₂ exchange from eddy-covariance measurements. Positive values are emissions from the soil. Negative values are CO₂ uptake by vegetation.

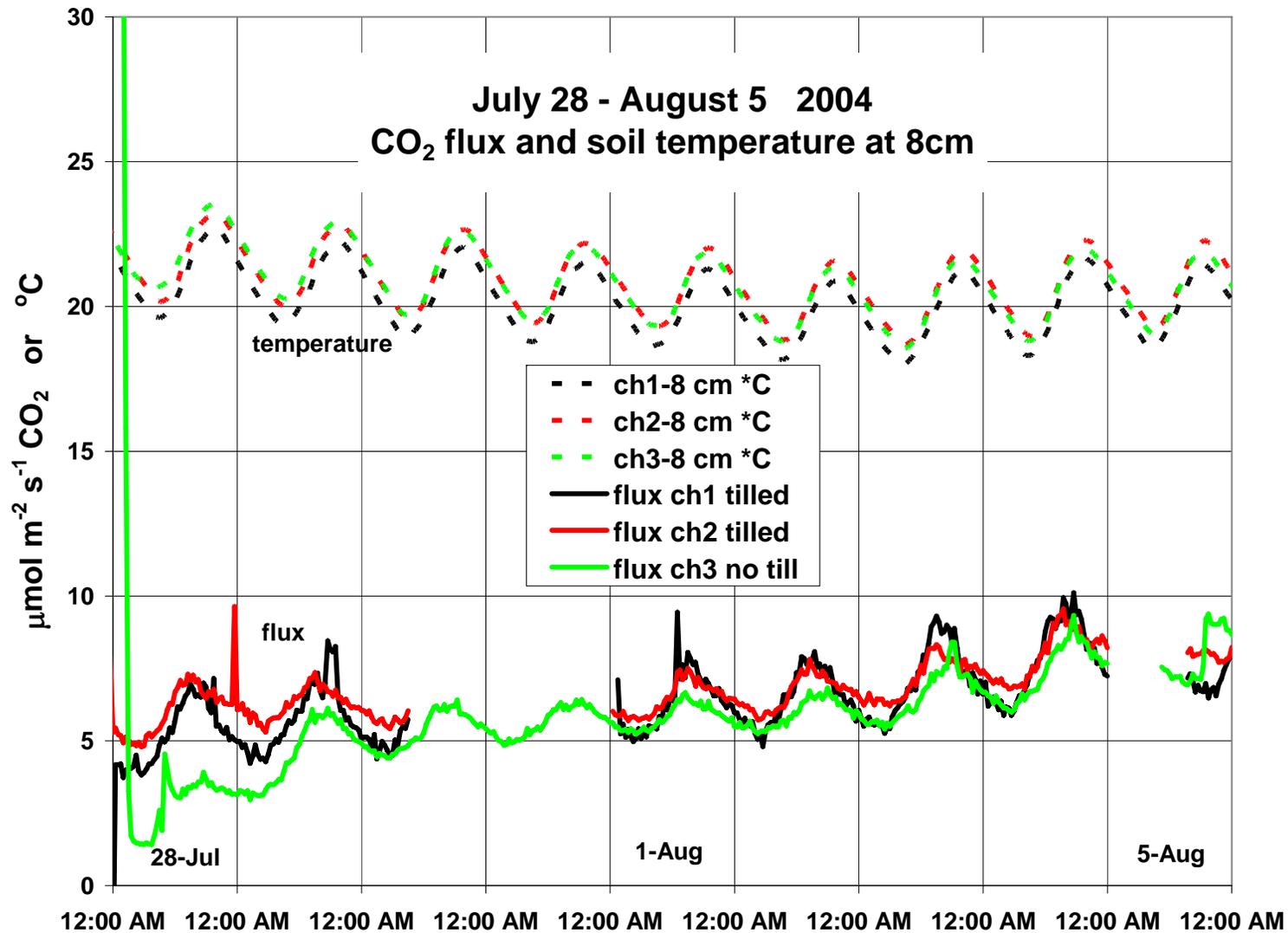
See Paw U et al.
poster



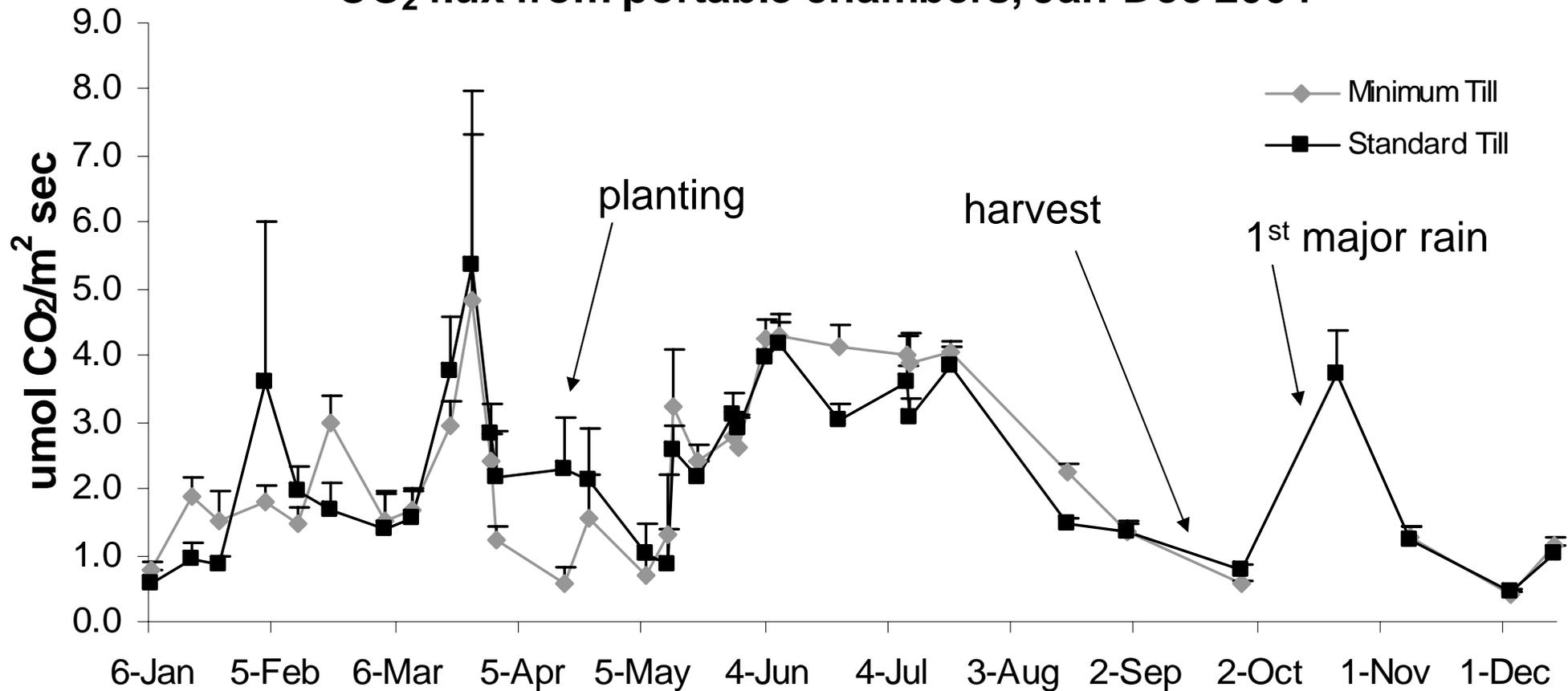
Plant and hand-harvest yield characteristics due to tillage treatment



CO₂ flux & soil temperature are measured 24 hrs/day in automated gas chambers in both treatments.

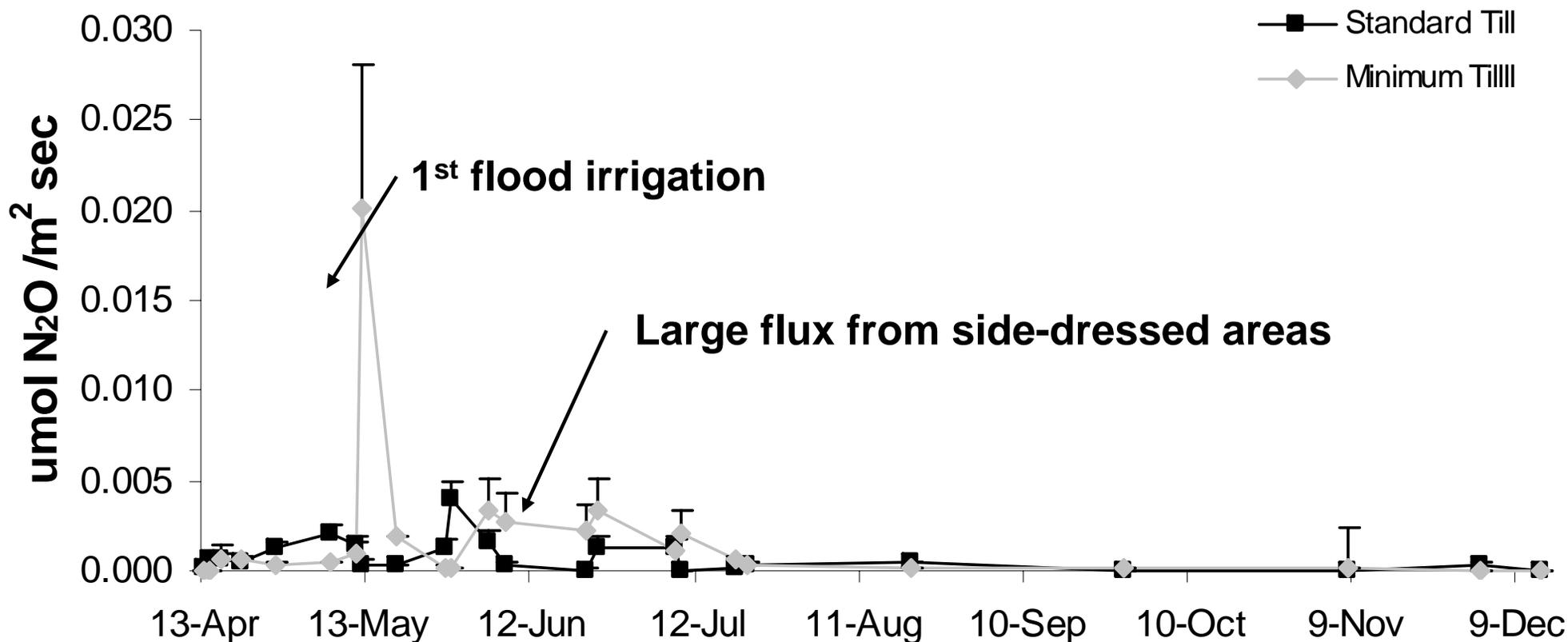


CO₂ flux from portable chambers, Jan-Dec 2004



- Temporal flux related to trends in soil temp. and water content. Large spatial variability (see posters of Lee et al. & Shaver et al.).
- Late Oct flux occurred 1 day after first rain
- Little or no difference in flux due to tillage treatment
- Flux during winter from furrows in MT > ST due to large amount of crop residue in furrows

N₂O flux from portable chambers, April - December 2004

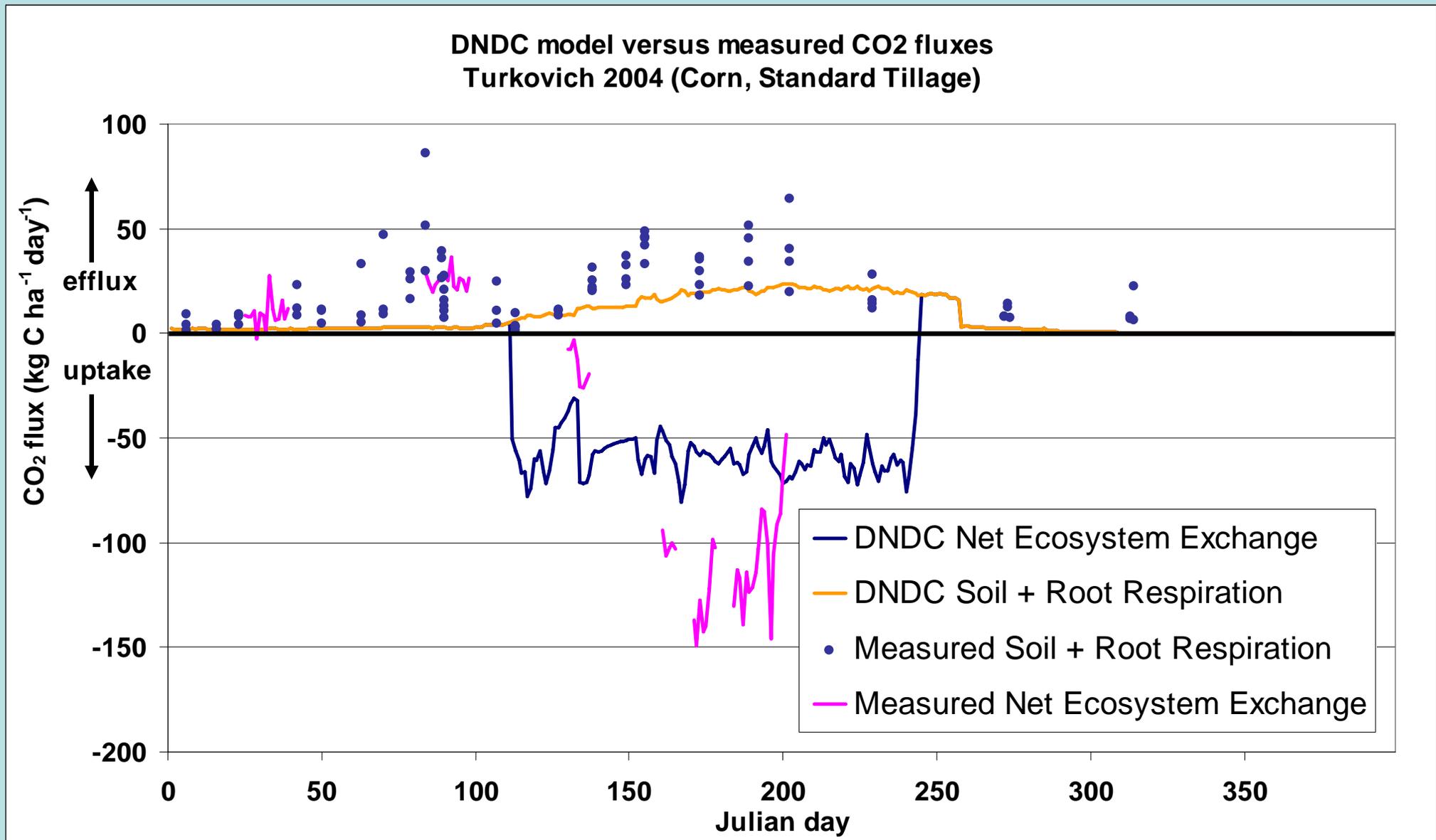


- Emissions of N₂O (& NO) occurred only after fertilizer applications
- Largest emissions occurred directly over the fertilizer injection band
- Minor differences in flux due to tillage treatment

C and N cycle modeling

- Models as tools to “scale up” from the plot/field to landscape and regional scale
- We plan to use two “landscape-scale” models
 - DNDC
 - DayCent
- Models tested by comparing simulations to our field data
- Tested models then used to simulate C sequestration and greenhouse gas emissions at landscape and regional scales and connect to economic models

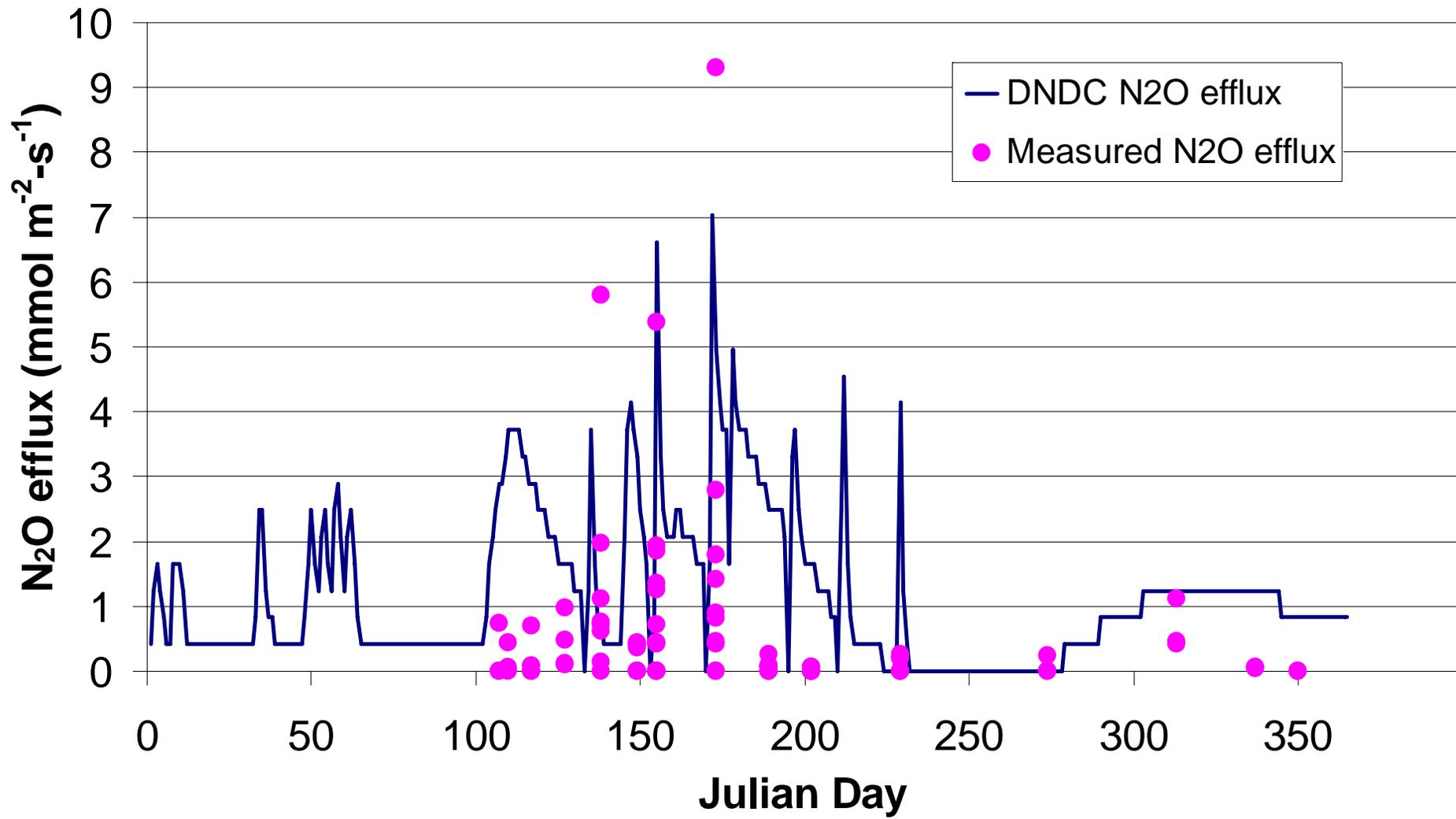
Initial model testing with field data



See poster by Adam Wolf et al.

Initial model test for N₂O

DNDC model versus measured N₂O budget
Turkovich 2004 (Corn, Standard Tillage)



Conclusions so far

- Eddy-covariance approach allows detection of C inputs and outputs not possible with chambers or soil sampling
- CO₂ fluxes from chambers compare well with fluxes of respiration from eddy covariance
- Could not detect increased CO₂ emission following incorporation of wheat residue
- Measurable N₂O and NO emissions occur only after fertilizer application, and only small differences due to tillage
- Initial simulations with DNDC may indicate some underestimation of CO₂ emission but reasonable estimates for N₂O

Ongoing research

- Continue all measurements described above
- Use spatial statistical tools to visualize and correlate landscape-scale patterns of soil C and N and physical and chemical properties with greenhouse gas emissions and C sequestration
- Compare DNDC and DayCent simulations with field data and couple these models to an economic model